Quantitative Effects of Early and Late Blights on Tomato Yields in Cameroon

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Keywords: *Alternaria solani*- Disease control- *Phytophthora infestans*

Summary

Early blight caused by Alternaria solani *and late blight caused by* Phytophthora infestans *are the major diseases of tomato (*Lycopersicon esculentum*) in Cameroon. The effect of both diseases on fruit yield was evaluated during the 1995 growing season in Dschang, Cameroon. Ten varieties were planted in the first trial (March-July) and nine in the second (July-November). In both trials, plots were sprayed weekly with Ridomil Plus (2.0 kg/ha) before flowering and with maneb (1.6 kg/ha) after flowering. Early blight was more severe in the early part of the first trial, while late blight caused most damage during the second. Marketable yields varied according to variety. High yields in sprayed plots were obtained in Dona F1 (61.63 t/ha) and Heinz 1370 (68.24 t/ha) during the first trial, and in Fline (58.35 t/ha), Mecline (64.25 t/ha), and Moboline (55.16 t/ha) during the second trial. Percent fruit infection in sprayed plots caused by both diseases varied according to variety from 12 to 65% in the first season and from 14 to 52% in the second, while losses in marketable yields for both blights were as high as 100% in unsprayed plots.*

Résumé

Effets quantitatifs de l'alternariose et du mildiou sur le rendement de la tomate au Cameroun

L'alternariose causée par Alternaria solani *et le mildiou causé par* Phytophthora infestans *constituent les maladies les plus importantes de la tomate (*Lycopersicon esculentum*) au Cameroun. L'effet des deux maladies sur le rendement en fruit a été évalué pendant la saison culturale de 1995 à Dschang, Cameroun. Dix variétés de tomate ont été semées dans la première saison (mars-juillet) et neuf dans la deuxième (juillet-novembre). Pendant les deux saisons, les parcelles ont été traitées chaque semaine au Ridomil Plus (2,0 kg/ha) avant la floraison et au manèbe (1,6 kg/ha) après la floraison. L'alternariose a été plus sévère dans la première saison, alors que le mildiou a causé les pertes les plus élevées dans la deuxième saison. Les rendements commercialisables ont varié selon la variété. Les rendements ont été élevés pour la variété Dona F1 (61,63 t/ha) et Heinz 1370 (68,24 t/ha) en première saison, et de Fline (58,35 t/ha), Mecline (64,25 t/ha), et Moboline (55,16 t/ha) dans la deuxième saison. Le pourcentage de fruits infectés par les deux maladies dans les parcelles traitées a varié de 12 à 65% dans la première saison et de 14 à 52% dans la deuxième, tandis que les pertes en rendement commercial causées par les deux maladies ont atteint 100% dans les parcelles non traitées.*

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is the most widely cultivated vegetable in Cameroon (19). Although, it is grown as a subsistence crop in all agro-ecological regions of the country, commercial fields are mostly found in the highlands of the West Province, where climatic conditions are conducive to tomato growing. Most tomatoes produced are consumed locally while about 1% is exported to neighbouring countries (19).

Annual tomato production in Cameroon is estimated at 76 000 tonnes (19) and the average yield is evaluated at 4 t/ha (4). This yield figure is very low compared to the African (19 t/ha) or world (28 t/ha) yields (4). The low yield may be attributed to the susceptibility of the crop to diseases (5, 10-12). Foliage and fruit infections by early blight (caused by *Alternaria solani* (Ell. & Martin) Sor.) and late blight (caused by *Phytophthora infestans* (Mont.) de Bary) contribute to these yield losses (5, 10-13). Tomato varieties usually perform very poorly in the field under humid tropical conditions (1, 10-12, 15). Although several varieties have been screened for resistance to late blight, resistant ones have not reported at the farmers' level in Cameroon (11). Consequently, tomatoes are produced under an intensive fungicidal spray regime and early and late blight management forms an integral component of cultural techniques in tomato production in Cameroon (10). However, pesticides in general are costly to resource-poor farmers. Moreover, chemical control measures using conventional fungicides may leave toxic residues that may present potential dangers to the environment and consumers. The identification of high yielding varieties is necessary to select those that could be included in breeding and extension programmes.

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Studies conducted on potato in Cameroon have revealed a close relationship between both early and late blight infections and tuber yields (6-9). The objective of this work was to evaluate the yield potential of tomato varieties as affected by early and late blight infections in the highland agro-ecology of Cameroon.

Materials and methods

Experimental site and design

Two trials were conducted during 1995 in Dschang (5°35'N, 10°05'E, 1400 m), to assess the effect of early and late blight infections on tomato yields. Mean daily temperature, relative humidity and rainfall were recorded during the entire research period.

The field used had not be grown with any solanaceous crop during the past three years. The soil type for both trials is typic paleustult (dystric nitrosol) (pH- H_2O 5.0; CEC 33 meq/ 100 g soil, 13:35:52 sand/loam/clay). In both trials, a split block design was used with three replicates. In the first trial, each block, measuring 10.6 x 24.0 m, was sub-divided into 20 plots, while in the second, each block, measuring 10.6 x 21.6 m, was sub-divided into 18 plots. Half of the plots received fungicidal protection, while the other half was not sprayed. In both trials, varieties were randomly assigned to plots. Each plot contained three raised beds of twelve plants each (4.8 x 2.4 m). Blocks were separated by an uncultivated land 2 m wide.

Cultural techniques

Ten fresh market tomato varieties purchased in local shops in Dschang were used in the first trial (March-July) while nine were used during the second trial (July-November) (Table 1).

Two locally cultivated varieties, Roma VF and Rio Grande, were included in both trials. In either trial, the nursery bed was fertilised with 50 kg/ha chicken droppings. The nursery was set up on 9 March in the first trial and 8 July in the second. Seeds were drilled 5 cm apart in rows spaced 10 cm. After sowing, beds were shaded with grass mulch until germination was completed. After germination, plants were sprayed twice before transplanting with Ridomil Plus (72 WP) at 2 kg/ha. Ridomil Plus is a co-formulation of 12% systemic fungicide metalaxyl and 60% contact cuprous oxide.

Seedlings were transplanted when plants had developed 4-5 true leaves (8 April and 14 August). They were planted in rows spaced 0.80 m apart with 0.40 m between plants within the row. Plots were base-fertilised with 36:18:60 kg/ha N-P-K and 1200 kg/ha chicken dropping (3:2:4 N-P-K) before transplanting. Three sprays of a foliar fertiliser, Fertigofol 313 (4 l/ha) were applied on leaves every two weeks starting from fruit formation. All plants were staked and the field was hand weeded as needed. In the first trial, an insecticide thiodan (Thiodan 35 EC, 0.38 l a.i./ha) was applied on the foliage to control aphids and the treatments were followed by four bi-weekly applications of 0.07 l/ha of deltalmethrin (Decis 25 EC) to control the melon fruit fly (*Dacus* sp.).

Fungicidal protection was initiated in both trials when plants were 10-15 cm in height (12 April and 18 August). Ridomil Plus (2 kg/ha) was applied weekly before flowering. This was followed by ten weekly applications of a contact fungicide, maneb (Manessan 80 WP), at 1.6 kg/ha. Control plots were not sprayed. All pesticides were applied with a Hardi knapsack

Table 1
Characteristics of tomato varieties used in both trials in Dschang, Cameroon

Trial	Variety	Origin	Growth pattern[x]	Fruit characteristics	
				Colour[y]	Size (g)
Trial 1	Dona F1	Vilmorin	SDet.	GB	145
	Heinz 1370	Technisem	Det.	UG	177
	Heinz 1439	Doights Verts	Det.	UG	130
	Marglobe	Doights Verts	Det.	GB	195
	Marmande	Pioneer	Det.	GB	85
	Market Wonder	Doights Verts	Det.	GB	120
	Rio Grande	Technisem	Det.	UG	60
	Roma VF	Pioneer	Det.	UG	55
	St Peter	Doights Verts	Det.	GB	130
	Xina	Technisem	Det.	UG	34
Trial 2	Caline	INRA[z]	Det.	UG	50
	Fline	INRA	Det.	GB	100
	Mecline	INRA	Det.	UG	33
	Moboline	INRA	SDet.	UG	73
	Pieline	INRA	Det.	UG	30
	Pieraline	INRA	SDet.	GB	113
	Piline	INRA	Det.	UG	30
	Rio Grande	Technisem	Det.	UG	60
	Roma VF	Pioneer	Det.	UG	55

[x] Growth pattern: determinate (Det.) or semi determinate (Sdet.).
[y] Mature fruit colour: uniform green (UG) or green back (GB).
[z] INRA= Institut National de la Recherche Agronomique, Avignon, France.

sprayer, using a spray volume of 700 l/ha at a maximum pressure of 7 kg/cm². A spreader-sticker, Tenac Plus (Shell Chemicals, Abidjan, Ivory Coast) was incorporated into the spray solution at 0.1% (v/v).

Disease and yield evaluations

Ten weekly severity ratings of early or late blight were scored on five randomly selected plants in the middle row of each plot using a modified Horsfall-Barratt rating scale of 1 to 12 (1= 0%, 12= 100% disease severity) (2). Assessments were initiated 14 days after transplanting (DAT) and 33 DAT in the first and second trials, respectively. Standardised area under disease-progress curve (SAUDPC), expressed in proportions, was calculated from disease severity data according to the formula proposed by Campbell and Madden (3). Mature fruits were hand-harvested twice per week from the central 10 plants in each plot. After eliminating diseased fruits, marketable fruits were counted and weighed, and marketable fresh yields were expressed in metric ton fresh wt/ha. Fruits were observed for incidence of early and late blight rots. Percent fruit rot incidence caused by early or late blight infection was assessed for each plot. Loss in marketable yield was computed for each variety according to the formula:

$$\% \text{ Loss} = 100*(Ys–Yu)/Ys$$

where Ys and Yu are yields in sprayed and unsprayed plots, respectively. Data were subjected to analysis of variance (ANOVA) using an MSTAT-C statistical package. Least significant differences (LSD, 0.05) were used to compare means between sprayed and unsprayed plots.

Results

Weather conditions

Monthly rainfall varied between 73 and 270 mm during March to July and between 47 to 325 mm during July to November 1995. Mean monthly relative humidity varied between 86 and 97%. Mean temperatures were generally higher (21.4-22.7 °C) during the first trial than the second (20.4-21.2 °C) (Figure 1).

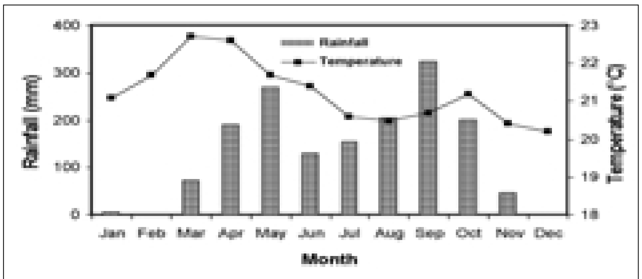

Figure 1: Monthly rainfall and daily temperature during 1995 in Dschang, Cameroon.

Effect of early blight infections on tomato yields

In the first trial, early blight appeared earlier and was more severe on plants than late blight. The former disease was first noticed in the seedbed and, despite fungicidal protection, infections were carried over to field crops. In unsprayed plots, symptoms of early blight developed from lower leaves to the upper ones and stem lesions were very common. Varieties Marglobe, Rio Grande and Roma VF were less susceptible to early blight compared to the rest of the ten varieties grown. For each variety, blight severity was low in sprayed plots compared to unsprayed plots. Blight severity values were lowest in Roma VF, followed by Rio Grande and Marglobe (Figure 2).

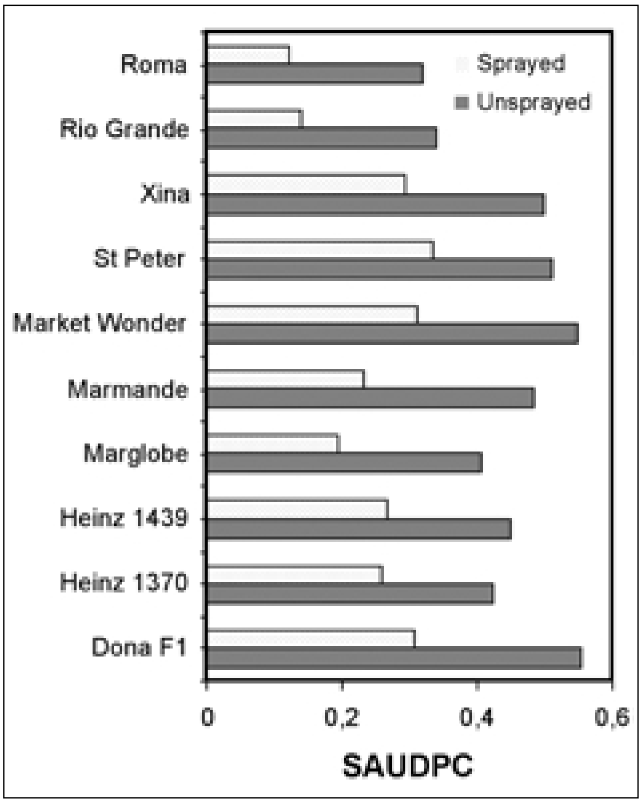

Figure 2: Standardised area under disease-progress curve (SAUDPC) for early blight infection in sprayed and unsprayed tomato varieties in Dschang, Cameroon.

Early blight infected fruits mostly from the stem end and caused premature fruit abscission. Late blight symptoms appeared later during the first trial. They were first detected on Rio Grande and Roma VF on 3 June. Symptoms were limited to the leaves that were not yet infected with early blight. On the whole, late blight caused less than 10% fruit infection while early blight was responsible for most of the fruit rots.

An analysis of variance for marketable yields revealed that the effects of variety x fungicide interactions were not significant. The highest yielding varieties in unsprayed plots were Heinz 1370, Heinz 1439 and Marglobe. Fungicidal treatments significantly reduced the percentage of diseased fruits. Percent fruit infection ranged 63 to 100% in unsprayed plots and 12 to 65% in plots exposed to fungicidal protection (Table 2).

Table 2
Marketable yield, percent fruit infection and percent loss in tomato attributable to early blight in Dschang, Cameroon

Variety	Marketable yield (t/ha)		% Fruit infection		% Loss in yield[y]
	Unsprayed	Sprayed	Unsprayed	Sprayed	
Dona F1	17.26 ± 3.34 b[z]	61.63 ± 3.31 a	68	32	73
Heinz 1370	32.05 ± 2.57 a	68.24 ± 4.44 a	63	15	59
Heinz 1439	31.35 ± 2.87 a	52.84 ± 2.20 b	84	21	41
Marglobe	29.48 ± 4.44 a	51.42 ± 1.87 bc	73	31	43
Marmande	0.0 ± 0 d	33.65 ± 5.53 cd	100	37	100
Market Wonder	0.0 ± 0 d	19.44 ± 3.51 f	100	65	100
St Peter	6.74 ± 1.44 c	48.16 ± 2.16 c	96	17	86
Xina	11.88 ± 2.69 bc	22.95 ± 3.53 ef	86	29	48
Rio Grande	0.0 ± 0 d	30.24 ± 1.71 de	100	26	100
Roma VF	7.18 ± 2.34 c	50.32 ± 2.52 c	81	12	85
LSD(0.05)	6.87	8.44	–	–	–
CV (%)	18.37	13.28	–	–	–

[y] Loss was computed for each variety according to the formula: % Loss= 100*(Ys – Yu)/Ys, where Yu and Ys are the marketable yields in unsprayed and sprayed plots, respectively.
[z] Means within a column followed by different letters are significantly different according to Fisher's LSD (P= 0.05).

Some plots that were not protected against disease infection did not yield any marketable fruits. Losses in marketable yield by unprotected plots when compared to protected plots were 41- 100%. Total (100%) losses were recorded in Marmande, Market Wonder, and Rio Grande plots, while the lowest losses were obtained in Heinz 1439 and Marglobe plots (Table 2).

Effect of late blight infections on tomato yields

In the second trial, late blight was more common on all plants, while early blight infections were negligible. All varieties were susceptible to late blight although Pieraline, Moboline and Mecline were less blight susceptible compared to the others. All the sprayed plots recorded a significant reduction in disease severity compared to the unsprayed plots, where high blight infections were noticed during the whole season (Figure 3).

As for the first trial, yields varied according to variety. Varieties Fline, Mecline, Moboline, and Pieraline outyielded the local varieties, Roma VF and Rio Grande (Table 3). The highest yields in sprayed plots were recorded on Mecline (64.25 t/ha), followed by Fline (58.35 t/ha), Moboline (55.16 t/ha), and Pieraline (52.35 t/ha), while the lowest were obtained on Rio Grande (17.26 t/ha) and Roma VF (28.00 t/ha) (Table 3).

Fruit infections were mostly caused by late blight. Percent fruit infection in sprayed plots was low in Pieraline (14%), followed by Mecline (16%) and high in Roma VF (52%) and Rio Grande (36%). Except for Mecline, Moboline and Pieraline, all fruits in unsprayed plots were infected with late blight and were not marketable. Consequently, marketable yields were not recorded. As for early blight infection, yield losses of up to 100% were recorded in unsprayed plots (Table 3).

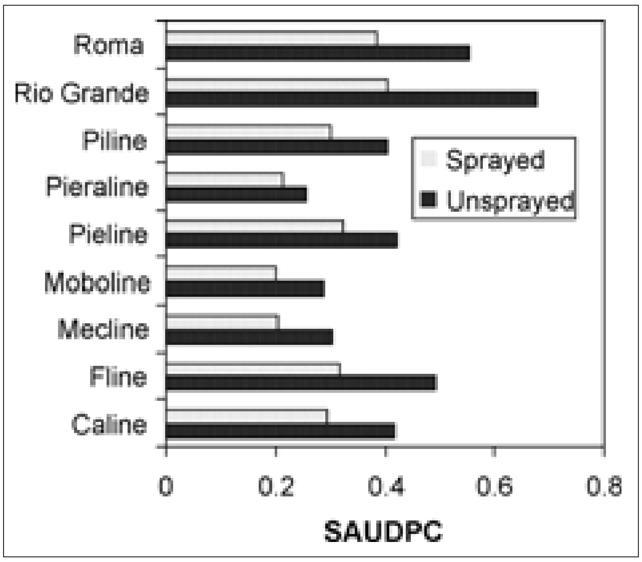

Figure 3: Standardised area under disease progress curve (SAUDPC) for late blight infection in sprayed and unsprayed tomato varieties in Dschang, Cameroon.

Discussion

Although early and late blights require a high humidity (90-100%) for optimal development, late blight usually requires lower temperatures for conidial growth and development than early blight (14). The optimum temperature for sporangial formation in *P. infestans* is 18 to 22 °C while *A. solani* requires an optimum temperature of 28 to 30 °C for conidial germination (14). Accordingly, high temperatures during the first trial are conducive to the development of early blight, while low temperatures during the second trial favour late blight development. Consequently, early blight was more severe in the early part of the wet season, while late blight caused most damage in the late wet season. Furthermore, fruit rots were mostly caused by early

Table 3
Marketable yield (t/ha), percent fruit rot and percent loss in tomato attributable to late blight in Dschang, Cameroon

Variety	Marketable yield (t/ha)		% Deseased fruit		% Loss in yield[y]
	Unsprayed	Sprayed	Unsprayed	Sprayed	
Caline	0 ± 0 c[z]	30.25 ± 5.34 c	100	25	100
Fline	0 ± 0 c	58.35 ± 3.16 a	100	30	100
Mecline	17.64 ± 3.56 a	64.25 ± 4.54 a	63	16	73
Moboline	7.50 ± 2.41 b	55.16 ± 6.89 a	74	23	82
Pieline	0 ± 0 c	30.00 ± 4.88 c	100	28	100
Pieraline	5.88 ± 2.87 bc	52.35 ± 3.36 ab	73	14	89
Piline	0 ± 0 c	40.00 ± 5.52 bc	100	33	100
Rio Grande	0 ± 0 c	17.26 ± 2.68 d	100	36	100
Roma VF	0 ± 0 c	28.00 ± 2.25 cd	100	52	100
LSD(0.05)	7.32	12.51	–	–	–
CV %	21.85	17.34	–	–	–

[y] Loss was computed for each variety according to the formula: % Loss= 100*(Ys–Yu)/Ys, where Yu and Ys are the marketable yields in unsprayed and sprayed plots, respectively.
[z] Means within a column followed by different letters are significantly different according to Fisher's LSD (P= 0.05).

blight infections in the first trial and by late blight infections in the second trial.

Both blights are a threat to the tomato and potato industries in Cameroon (6-12), where disease resistant varieties are not always available to farmers. Fruit rot incidence recorded in sprayed plots due to both diseases varied according to variety from 12-65% in the first trial and 14-52% in the second. Total fruit losses (100% loss) were recorded in unsprayed plots of Marmande, Market Wonder and Rio Grande in the first trial and Caline, Fline, Pieline, Piline, Rio Grande and Roma in the second trial. This suggests a need for an appropriate blight management in tomato farming.

Despite the weekly fungicidal spray schedule used in either trial, percent fruit infection recorded in sprayed plots was still high, indicating that the weekly spray schedule was not enough to control either blight. In Taiwan, Hartman and Huang (13) also obtained effective control of tomato late blight with weekly applications of metalaxyl, although late blight caused 54% fruit infection and about 59% yield losses. In our previous studies (12), weekly sprays of maneb, mancozèbe or Ridomil MZ did not adequately limit late blight losses in tomatoes. In Indonesia, spray intervals of four days were reported to be more effective against late blight although disease incidence was also reported to be high (17, 18). In Uganda, two sprays of mancozeb per week are recommended for an integrated disease management system for tomato late blight (1, 15). Many tomato growers in Cameroon feel that 2-3 fungicidal sprays per week are necessary on tomatoes during the wet season (10).

This study reveals that the weekly spray schedule is inadequate to completely limit late blight losses in tomato fruits. Consequently, it is necessary to investigate on alternative, less polluting methods of blight control. Shtienberg *et al*. (16) suggested the incorporation of host resistance in a reduced spray strategy to control both blights in potato. According to this strategy, sprays are initiated when late blight is predicted by a forecast or when the severity of early blight is predicted to become important (6-7 wk after planting).

Conclusions

Results of this study show that early and late blights are severe diseases in tomato fields in Cameroon. The mean yield loss attributable to late blight damage was as high as 100%. Varieties Dona F1 and Heinz 1370 in the first trial and Fline, Mecline and Moboline in the second trial out-yielded Roma VF or Rio Grande, that are the most widely grown varieties in Cameroon (10). However, production of these varieties would require sound disease management practices, such as fungicide protection and field sanitation (6). Results suggest that appropriate blight management programmes are necessary to limit fruit losses due to early and late blights in the wet season in Cameroon.

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